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Locational Conditions, Cooperation and Innovativeness: Evidence from Research and Company Spin-Offs

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Locational Conditions, Cooperation, and Innovativeness: Evidence from Research and Company Spin-Offs[§]

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Abstract

This paper has two goals. First, it analyzes the extent to which the innovativeness of spin-offs, either born from a research facility or from another company, is influenced by locational conditions. Second, it provides evidence on how important local cooperation links are in comparison to nonlocal ones. Using a sample of approximately 1,500 East German firms from knowledge-intensive sectors, we estimate a structural equation model applying the partial least squares method. We find that proximity to local research institutes and universities is the most influential factor for the cooperation intensity of spin-offs. Furthermore, the higher the cooperation intensity, the greater the innovativeness of a firm. Moreover, the results indicate that it is not the local but the nonlocal cooperation ties that are more conducive to innovativeness of research spin-offs. The findings also highlight that the innovativeness of research spin-offs with solely local links is strongly depends on support from various authorities and institutions.

Keywords: *Research and Company Spin-Offs, Locational Conditions, Cooperation Intensity, Innovativeness, Structural Equation Modeling, Partial Least Squares Approach*

JEL classification: M13, O18, R3

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1. Introduction

The unique role of spin-off companies in the economy is much discussed in the literature. Spin-offs act not only as product innovators, but also as a means of transferring knowledge and technology from research facilities to companies. Thus, many studies focus on the creation and development of spin-offs, and this literature stresses the importance of proximity to knowledge source and the role of public authority and parent organization support, as well potential benefits resulting from the firm environment (Beise and Stahl 1999, Callan 2001, Garvin 1983, Klepper and Sleeper 2005, Koster 2006, Mustar 1998, Turner 2000). However, there is very little empirical evidence on the role that geography and locational patterns play in the innovativeness of already established spin-offs. This paper is intended to fill this gap.

Building on empirical research into the relationship between location and the innovativeness of firms in the knowledge-intensive sectors (such as electronics, biotechnology, or IT), we intend to discover the answers to three questions. (1) To what extent do locational conditions (e.g., proximity to research facilities or various types of support from regional authorities) influence the cooperation activities and innovativeness of spin-offs? (2) Does cooperation have an effect on spin-off innovativeness, and if so, is it local or nonlocal cooperation that is the more conducive to innovativeness? (3) How important is entry type, i.e., research vs. company origin of the spin-off, for the firm's innovativeness and performance?

It is important to note that we disentangle the effect of locational conditions on innovativeness by taking into account the possibility of an indirect effect via the cooperation activities of spin-offs. We do this because although many authors have argued that proximity to cooperation partners is crucial to the innovation process (for example, Audretsch and Feldman 1996, Jensen and Thursby 2001, Keeble et al. 1998, Longhi 1999, Mowery and Ziedonis 2001, Porter 2000), others have found that a great number of the collaboration ties enjoyed by knowledge-intensive firms are with nonlocal-based partners (Audretsch and Stephan 1996, Egeln et al. 2004).

Furthermore, the vast majority of previous studies on spin-offs concentrates either on research spin-offs (also known as university, academic, or public spin-offs) only or company spin-offs (sometimes termed corporate spin-offs) only. Thus, another feature of our paper is that we take both types of spin-offs into consideration and provide results for each. Other forms of firm creation are also analyzed in order investigate whether the kind of firm entry influences the innovativeness and performance of firms at later stages of development.

The basis for our study is a sample of East German firms collected in a large survey in the year 2004. In this survey, firms provided information about, inter alia, their innovativeness (e.g., new products, number of patent applications, or amount spent on R&D) and about their cooperation activities (e.g., collaboration frequency or geographical proximity to their partners). Moreover, firms assessed the importance and quality of 12 locational conditions, such as availability of skilled labor, transportation links, and support from local authorities. Although it is true that a firm's assessment of locational conditions may not reflect the objective reality of same (e.g., perceived vs. actual distance from an airport or university), the perceptions, objectively true or not, of potential decisionmakers are crucial because these perceptions can influence decisions they may make about the spatial scope of their economic activities. Since regional systems can be regarded as a cumulative outcome derived from decisions of various individual economic actors, it is necessary to take the firms' viewpoint into consideration when performing a spatial analysis (Britton 2004, Oerlemans et al. 2001, Rees and Stafford 1986).

Another aspect that distinguishes our study from other research on this topic is that many studies of spin-offs are based on data derived from famous clusters such as Silicon Valley, Boston Route 128, or Cambridge (Massachusetts) (Clayton et al. 1999, Keeble et al. 1998, Saxenian 1994, Shane 2004), but our analysis is based on firms located in a more disadvantaged region—East Germany (e.g., Kronthaler 2005, Niefert et al. 2006). Locational conditions have improved significantly in many East German regions over the last 15 years, but there is still a strong heterogeneity among regions (Fritsch et al. 2007). Given this variation of locational conditions for firms in our sample, these data are very suitable for testing locational effects.

The next section sets out the theoretical background of our study, including the definition of a "spin-off company" used in this paper, a review of selected literature on spin-offs, a description of the hypotheses included in our structural equation model, and an outline of the methodology to be employed. Section 3 provides a description of the data. Section 4 presents and discusses the estimation results. We conclude in Section 5 by discussing some of the implications of our study.

2. Theoretical Background

2.1 Research Spin-Off vs. Company Spin-Off

Despite a growing body of research into spin-offs in recent years, there is, as yet, no commonly accepted definition of a spin-off. The vast majority of studies define a spin-off as a firm whose intellectual capital somehow originates from its parent institution, which may be a university, a research institute, or another company. However, the definitions used by different authors cover a wide variety of affiliations between the spin-off company and its parent organization, including everything from knowledge transfer (occurring by, e.g., personnel links, providing technology, and/or existing products) to equity financing (Callan 2001, Klepper and Sleeper 2005, Meyer 2003).

In this paper, we distinguish between research spin-offs and company spin-offs. *Research spin-offs* are defined as firms originating from a university or research institute and that have a former or present employee of that facility as one of the founders. *Company spin-offs* are defined as firms created by splitting off from a preexisting company. We make a distinction between these two types of spin-offs because of their different characteristics, which may be rooted in the vast dissimilarity of their parent organizations. Lindholm Dahlstrand (1997) argues that universities are interested in publishing and using their research outside the university, whereas private companies often try to keep knowledge and technology within the firm. Universities may assist research spin-offs, particularly during the research and product development phases, by, e.g., enabling access to laboratories or part-time employment of the future spin-off founders (see, e.g., Egeln et al. 2002, Mustar 1997, Shane 2004). In contrast, company spin-offs may receive more support from their parent companies during the production and commercialization phases by, e.g., providing supplier and customer contacts or already established marketing channels (e.g., Clayton et al. 1999, Garvin 1983).

We realize that our rather vague specification of the relationship between a spin-off and its parent organization might raise some concern about the usefulness of our definition; however, analysis of this specific connection is not the focus of this study. In fact, we go beyond the existing work on spin-offs (e.g., Egeln et al. 2004, Jensen and Thursby 2001, Zucker et al. 1998) and take a variety of cooperation partners, not just the parent institutions, into consideration. Moreover, due to the nature of the data used in this study, we avoid the potential selection bias inherent in many previous spin-off studies that are based on survey data derived from the parent institutions (see Callan 2001 for a summary of the data sources used in many studies on spin-offs in OECD countries).

2.2 Recent Literature on Spin-Offs: Innovativeness and Location Pattern

2.2.1 Innovativeness

Although the literature often discusses the high innovation potential of (particularly research) spin-offs in their preliminary development phase (for a literature overview on spin-offs, see Helm and Mauroner 2007), there is to date very little empirical evidence on how the innovativeness of established spin-offs compares to that of firms established by other forms of market entry.

Lindholm Dahlstrand (1997) compares the background and performance (in terms of growth and innovativeness) of spin-offs and non-spin-off firms. To this end, data from 60 small Swedish technology-based established firms are used; among these firms, there are 30 spin-offs. Two-thirds of the spin-offs had emerged from private firms (i.e., company spin-offs) and one-sixth were related to universities (i.e., research spin-offs). In the analysis, no distinction was made between the research and company spin-offs. It was found that the spin-offs enjoyed a higher degree of technology transfer and sales growth than did the non-spin-offs. However, the difference between the two groups regarding innovativeness appeared to be insignificant, possibly because firm innovativeness was measured by only one indicator, i.e., the number of patents. Other relevant indicators of innovativeness, such as introducing new products on the market or developing new processes, were not considered.

2.2.2 Location Pattern

Existing literature makes it clear that geographic location has a significant influence on spin-off activity across countries and regions.[1] In the OECD STI Review (2001) on research spin-offs, Mustar (2001) highlights a local dimension of spin-offs that is embodied in the spatial proximity between spin-offs and their parent institutions (primarily universities) as well the local innovation networks. That geographical proximity to knowledge source is a critical success factor is assumed by many other empirical studies also.

For example, Zucker et al. (1998) investigates the location determinants of nearly 700 biotechnology firms in the United States. Both new firms (entrants) and new subunits of existing firms (incumbents) are included in the analysis. It was found that intellectual human capital, measured separately in terms of the presence of star scientists and top-quality universities, has a strong positive impact on the location of the biotechnology industry. Moreover, birth of new firms is positively influenced by federal research grants. In addition, using data on licensed patents from three U.S. universities (University of California, Stanford University, and Columbia University), Mowery and Ziedonis (2001) show that knowledge flows from university inventions appear to be more geographically localized if they occur through market channels (licenses) than if they are due to nonmarket spillovers (patent citations). Moreover, the results of Jensen and Thursby's (2001) study on the licensing practices of U.S. universities make clear that most university inventions could not be made by either the inventor or the firm. Due to the fact that the vast majority of licensed inventions are in an embryonic phase, the university technology managers consider inventor cooperation in further development as crucial to commercial success.

However, Egeln et al. (2004) come to a somewhat different conclusion regarding the issue of geographic proximity between spin-offs and their parent organizations. In their paper, the authors investigate the location pattern and the determinants of location decisions of spin-offs from public research institutions in Germany. They find that a significant percentage of spin-offs do not, in fact, locate near their parent institutions (more than 30 percent locate outside a 50-kilometer radius); however, about 55 percent of the spin-offs are located closer (e.g., within 25 kilometers) to their parent institutions. Moreover, spin-offs tend to move away from the region of their parent institution if, inter alia, the urbanization economies are less pronounced and as the time span between leaving employment with a public research facility and starting an own business increases. Finally, the authors report that although concentration of highly qualified personnel positively influences how many spin-offs stay in the same region as the parent, the need for highly trained staff does not significantly determine a spin-off's decision to move from the parent's region.

[1] For example, Pressman (2002) and Wright et al. (2002), in their comparisons of national rates of spin-off activities per license and per dollar of R&D expenditure, respectively, show that university spin-off activity varies significantly across countries. Shane (2004) suggests that this variation at the national level might originate in differences in access to capital, locus of property rights and licensing policy, rigidity of the academic labor market, and the industrial composition of the area.

2.3 Theoretical Concept: Hypotheses, Methodological Issues, and Model Specification

Focusing as it does primarily on proximity to research facilities, the literature on location patterns of spin-offs neglects to investigate the role of other spatial variables that may be crucial to firm innovativeness, such as the regional factor endowment or the geography of connections between cooperation partners (not only universities). Thus, the goal of this paper is to examine the relative importance of various locational conditions and spatial scope of collaboration links on the innovativeness of spin-offs. Below, we present our hypotheses, explain the estimation method employed, and develop the structural equation model.

2.3.1 Hypotheses

One thing that is common across the spin-off literature, regardless of differences in data and methodologies, is that access to knowledge is assumed to be a very important locational determinant for firms in knowledge-intensive sectors (see, e.g., Beise and Stahl 1999, Feldman 1999, Rees and Stafford 1986, Stöhr 1986). The knowledge can be obtained from various sources, including skilled labor, research institutions, collaboration, and networking. The literature also stresses the role of public authorities and financial institutions in firm innovativeness (e.g., Longhi 1999, Meyer 2003). This pivotal role includes a wide range of support—financial (e.g., seed capital, R&D grants, network-building grants), incubation programs, commercial advice, and consultancy, among others. The traditional friction-of-distance considerations involving transportation are of little relevance to knowledge-intensive firms; indeed, transportation costs comprise a rather small proportion of costs for these firms. However, transportation may be an important locational condition in terms of the general availability of the infrastructure (Rees and Stafford 1986). In fact, good-quality transportation infrastructure enables easier access to cooperation partners, suppliers, and customers.

As Gordon (1991: 178) puts it: "Geographic areas are championed as autonomous reservoirs of 'regional innovation potential' derived from specific locational attributes (research institutions, high levels of scientific and technical expertise, venture capital operations, 'quality of life' amenities, and non-unionized economic environment) that literally incubate small-firm, high technology growth." Hence, the potential and quality of the firm's location can be viewed as the sum of potential inherent in a variety of locational conditions. Moreover, the impact of the location on firm economic activities can be resolved into the separate effects of various locational conditions, such as regional availability of skilled labor or support from local government. Thus, the main hypothesis of our paper is as follows.

Hypothesis 1: *Favorable locational conditions enhance the cooperation intensity, particularly with local partners, and the innovativeness of firms.*

Furthermore, many studies emphasize that key to the success of a firm's innovativeness is its ability to create strategic alliances with a variety of actors and its integration into diverse networks of interactive relationships and partnerships in various fields (see, e.g., Best 2001, Campagni 1991, Porter 2000). Moreover, collaboration and networking enable firms to expand their capacities and complement the resources required for their specialized activities (Richardson 1972). This reasoning can be summarized by the following hypothesis.

Hypothesis 2a: *High cooperation intensity enhances firm innovativeness.*

Findings from the literature are ambiguous regarding the issue of geographic proximity to cooperation partners. On the one hand, the vast majority of research claims that local and/or intra-regional collaboration links play a crucial role in firm development and innovativeness (e.g., Audretsch and Feldman 1996, Keeble et al. 1998, Longhi 1999, Mustar 2001, Zucker et al. 1998). However, these analyses are often concentrated on the networking systems of well-known clusters and locations and, therefore, it is questionable whether the results can be generalized to middle- or lower-ranked regions (Britton 2004, Egeln et al. 2004). Indeed, firms located in lower-rated regions may be compelled to collaborate with external partners in order to overcome locational disadvantages and achieve success in terms of innovativeness. Gordon argues that local relationships driven by largely informal mechanisms "are insufficient either to initiate or sustain creative activity as techno-economic complementarities force firms to incorporate extra-regional sources of innovation" (Gordon 1991: 190). Moreover, Mustar (1998) points out that the dependence of firms' success on local and/or nonlocal partnerships is associated with their development phase. While local ties appear to be crucial for the creation and early development of spin-offs, national and international alliances become important at later stages of development.

To capture the spatial scope of cooperation for established firms, we propose the following hypothesis.

Hypothesis 2b: *Nonlocal collaboration ties enhance the innovativeness of established spin-offs to a greater extent than do purely local links.*

Furthermore, according to our previous empirical findings on the positive relationship between innovativeness and firm performance (Eickelpasch et al. 2007), we expect the following to hold.

Hypothesis 3: *Firm performance is positively affected by innovativeness.*

As mentioned above, according to the literature, spin-offs, at least in their early development phase, have a higher potential for innovation than do firms that have entered the market via a different path.

Peters (2006) reports empirical evidence on the persistence of firm innovation behavior over time, finding that innovation experience in the past significantly enhances the probability of innovating in the future. Accordingly, our next hypothesis is:

Hypothesis 4a: *Spin-offs are more innovative than firms created in other ways.*

Furthermore, because of the assistance that spin-offs receive from parent organizations in the early stage of their development, e.g., access to laboratories, funds, and/or materials, it appears likely that spin-offs will continue to achieve higher performance compared to their non-spin-off peers in subsequent periods (see Helm and Mauroner 2007). Thus, based on these findings, we propose:

Hypothesis 4b: *Established spin-offs show better firm performance than firms created in other ways.*

2.3.2 Methodological Issues

To test our hypotheses on the relationships between locational conditions, cooperation intensity, innovativeness, and firm performance, we employ a structural equation model—for two reasons. First, such a model allows taking into consideration the multidimensionality (i.e., various aspects) of latent (directly unobserved) variables (LV). Second, its high flexibility in modeling various relationships enables us to disentangle the direct and indirect impacts of locational conditions on firm innovativeness.

We use the partial least squares (PLS) method to estimate our structural equation model. The flexible PLS method permits interplay between data analysis and traditional modeling based on the distribution assumptions of observables (Wold 1982a). In contrast to parameter-oriented covariance structure analysis (e.g., LISREL), PLS is variance-based, distribution-free, and prediction-oriented (Fornell and Cha 1994). The scores of the LVs are estimated explicitly as weighted aggregates of their observed, manifest variables (MV) (Wold 1980).

PLS modeling (such as LISREL) starts with the design of a conceptual arrow scheme representing hypothetical relationships, sometimes including the expected correlation signs between LVs and between MVs and their LVs (Wold 1982b). The latent constructs can be operationalized as reflective or formative measurement models. The reflective MVs (also called *effect indicators*) are reflected by the LV and should be highly correlated. The formative manifest variables (called *cause indicators*) are assumed to determine the LV and need not be correlated (Bagozzi 1994, Bollen and Lennox 1991, Coltman et al. 2008).

PLS estimation occurs in three stages: in the first iterative stage, the values of latent variables are estimated; in the second stage, the inner and outer weights are calculated; and in the third stage, the location parameters (means of LVs and intercepts of linear regression functions) are determined (Lohmöller 1989).

Since all our LVs are operationalized as formative measurement models (MVs represent different features of their LV), only the approach for evaluating the estimation results for these models is briefly described. In the first instance, before model estimation, strong multicollinearity among the MVs should be tested and avoided (Diamantopoulos and Winklhofer 2001). Accordingly, evaluation of estimation results in the structural model occurs by using the determination coefficient R^2 calculated for the endogenous latent constructs. Chin (1998a) classifies R^2 values of 0.19, 0.33, or 0.67 as weak, moderate, or substantial, respectively. Moreover, on the basis of changes in R^2 values, the effect size f^2 of a particular exogenous LV on an endogenous LV can be calculated.[2] f^2 values of 0.02, 0.15, or 0.35 indicate a small, medium, or large effect. Finally, in order to check the significance of the inner and outer weights, t-statistics are produced on the basis of the bootstrap technique by resampling with replacements from the original data (Tenenhaus et al. 2005).

2.3.3 Model Design

The complete structural model is presented in FIGURE 1. Various locational conditions, as assessed by the firms in our sample, are grouped into four exogenous LVs; namely, *skilled labor, transportation, research facilities*, and *support*. Furthermore, three endogenous LVs—*cooperation, innovativeness*, and *performance*—are formulated. The paths between the LVs represent the hypotheses set out above. To test hypotheses H1, H2, and H3, the basic model is used; to test H4, we extend the basic model by introducing two additional exogenous LVs (*RSO* and *CSO*)[3] that should capture the influence of the kind of firm entry (research spin-off or company spin-off) on firm innovativeness and performance.

[FIGURE 1 HERE]

The latent constructs are operationalized as follows:

- *LV: Skilled labor*[4]

  L1: Firm assessment of locational condition: supply of skilled labor

  L2: Firm assessment of locational condition: additional education supply
- *LV: Transportation*[4]

  T1: Firm assessment of locational condition: supra-regional transportation links

  T1: Firm assessment of locational condition: intra-regional transportation links

[2] Chin (1998a): $f^2 = (R^2_{included} - R^2_{excluded}) / (1 - R^2_{included})$.

[3] Both LVs are measured by only one indicator: a dummy variable that takes the value 1 if a firm is a research spin-off or a company spin-off, and 0 if it is firm created in another way.

[4] These variables are measured on a six-point Likert scale, ranging from 0 = "unimportant"; 1 = "important and very bad quality"; to 5 = "important and very good quality."

- *LV: Research facilities*[4]

  R1: Firm assessment of locational condition: proximity to universities

  R1: Firm assessment of locational condition: proximity to research institutes

- *LV: Support*[4]

  S1: Firm assessment of locational condition: support of local financial institutions

  S2: Firm assessment of locational condition: support of job centers

  S3: Firm assessment of locational condition: local government support

  S4: Firm assessment of locational condition: support from business development corporations

  S6: Firm assessment of locational condition: state government support

  S6: Firm assessment of locational condition: chambers' support

- *LV: Cooperation*[5]

  C1: Cooperation frequency: basic research

  C2: Cooperation frequency: product development

  C3: Cooperation frequency: process development

  C4: Cooperation frequency: additional education

  C5: Cooperation frequency: sales

- *LV: Innovativeness*[6]

  I1: New products in 2003/2004

  I2: New processes in 2003/2004

  I3: Number of patent applications in 2003/2004

  I4: Deployment share of R&D in 2003

- *LV: Performance*[7]

  P1: Firm assessment of competition in 2005/2006

  P2: Firm assessment of the development of market volume for a medium term

Our expectations are that all indicators will be positively related to their LVs.

3. Data and Descriptive Analysis

3.1 Samples Description

We perform our analysis on micro-level data collected by the German Institute for Economic Research (DIW Berlin) in a large survey.[8] This survey, entitled "Current Situation and Outlook of East German Firms," was sent to 30,000 firms in East Germany in the year 2004 (the response rate amounted to about 20 percent).

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[5] These variables are measured on a five-point Likert scale, ranging from 1 = "we do not cooperate"; 3 = "we cooperate sometimes"; to 5 = "we often cooperate."

[6] The first two indicators are dummy variables; the last two are measured on a metric scale.

[7] These variables are measured on a five-point Likert scale, ranging from 1 = "considerably worse" to 5 = "considerably better."

From the dataset of about 6,200 surveyed firms, we select 1,517 firms from knowledge-intensive sectors, using as selection criteria the OECD classifications of high and medium-high technology manufacturers, as well that of knowledge-intensive services (KIS) (see Götzfried 2004). The list of the NACE[9] codes for these sectors is presented in TABLE 1. As mentioned before, we distinguish between three groups of firms, namely, research spin-offs (79 firms),[10] company spin-offs (410 firms), and firms otherwise created (1,028 firms). About 30 percent of all research spin-offs are manufacturing firms; the remaining 70 percent are services. In the case of company spin-offs, this ratio is approximately 60 percent to 40 percent.

[TABLE 1 HERE]

FIGURE 2 shows the geographical distribution of the (a) research spin-offs and (b) company spin-offs in our dataset. There are 25 research spin-offs in Saxony (most of them in Dresden and Leipzig), 19 in the eastern part of Berlin, 16 in Thuringia (mainly in Jena and Erfurt), 9 in Mecklenburg-Vorpommern, and 5 each in Brandenburg (4 of them in Potsdam) and Saxony-Anhalt. About 25 percent of these companies are headquartered in the East German state capitals. The figure shows that the company spin-offs are rather unequally distributed across the states; approximately 50 percent of them are located in the southern part of East Germany (28 percent in Saxony and 20 percent in Thuringia).

[FIGURE 2 HERE]

TABLE 2 sets out the distribution of the three firm groups in three settlement types—agglomerations, urbanized regions, and rural regions (the assignment of the particular counties to the settlement types is shown in the map in Appendix). The vast majority of research spin-offs are located in agglomerations and urbanized regions (58 and 32 percent, respectively). Company spin-offs and otherwise created firms are more often located in rural regions than are research spin-offs.

[TABLE 2 HERE]

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8 The survey was carried out on behalf of the German Ministry of Education and Science.

9 NACE stands for Nomenclature générale des activités économiques, or, in English, Nomenclature of economic activities.

10 About 54 percent of the research spin-offs in our dataset are "descendants" of universities, the other 46 percent originated in other types of research institutes.

3.2 Firm Characteristics: Research and Company Spin-Offs vs. Otherwise Created Firms

TABLE 3 presents the means and standard deviations of the indicators included in our model, as well as other firm characteristics.[11] Note that the median value of the founding year is comparable for all firm groups. Employing on average about 14 persons, the research spin-offs are smaller than the otherwise created firms (26 employees). However, the company spin-offs are significantly bigger (about 38 employees). The research spin-offs employ more highly skilled workers than do the other two groups; these values average about 60 percent for the research spin-offs compared to 36 percent for each of the other types. Approximately one-third of all research spin-offs are integrated into innovation networks. Furthermore, the research spin-offs have, on average, higher cooperation frequency in the areas of basic research and product and process development; the company spin-offs more frequently cooperate in process development and additional education.

The research spin-offs, on average, have higher innovativeness than firms from the other groups; 90 percent of these firms brought new products to the market in 2003 or 2004 and 44 percent of them established new processes. The number of applications for patents and their deployment shares in R&D are three times larger than those of the other types of firms. Similarly, in general, the research spin-offs have better expectation-based performance than otherwise created firms, which may be due to the fact that the vast majority of the research spin-offs (71 percent) received governmental aid for R&D. Finally, both types of spin-off show, on average, higher export rates than otherwise created firms.

[TABLE 3 HERE]

3.3 Cooperation Activities of Research Spin-Offs

TABLE 4 sets out descriptive statistics regarding the cooperation activities of the research spin-offs.[12] The average share of these firms that cooperate in five various fields is about 55 percent, ranging from 47 percent of firms cooperating in basic research to a rate of 78 percent cooperating in product development.

On average, approximately 30 percent of the research spin-offs cooperate with other companies in various areas; as one may expect, this collaboration occurs most frequently in product development and sales. Only 11 percent of the research spin-offs collaborate with other firms in additional education. About 30 percent of the research spin-offs are in partnership with research facilities such as

[11] Our findings are similar to the results reported by Burchardt et al. (2007) on academic spin-offs in Germany, e.g., the average turnover and number of employees (after outlier exclusion) were about 1,000,000 EUR and 14, respectively, in 2004.
[12] Note that shares do not add up to 100 percent. Firms can be included in more than one category because, e.g., they can cooperate with both research facilities and other firms.

universities or research institutes, ranging from only 5 percent for sales to about 40 percent for basic research and product development.

Moreover, 35 percent of the research spin-offs collaborate with local (within 30-km radius from the company headquarter) partners; 30 percent collaborate with nonlocal (outside a 30-km radius from the firm location) partners. Thirteen percent of the research spin-offs cooperate both with local and nonlocal partners.

[TABLE 4 HERE]

4. Estimation Results and Discussion[13]

As discussed in the previous section, there is a considerable heterogeneity among firms and firm sub-samples in terms of, e.g., firm size and affiliation with a firm group or economic sector. To avoid the potential bias resulting from this heterogeneity, in the first stage of the analysis we eliminate these potential effects by regressing the manifest variables on control variables and using the residuals from these analyses in the subsequent step of analysis. The first-stage regression models are as follows:

$$MV_{ij} = D_i^{group} + \sum_{a=1}^{3} D_i^{age_a} + \sum_{s=1}^{5} D_i^{size_s} + \sum_{b=1}^{B} D_i^{branch_b} + \sum_{t=1}^{3} D_i^{settlement_t} + u_{ij},$$

where

MV_{ij} = (original) value of manifest variable *j* for firm *i*,

D_i^{group} = dummy variable for affiliation with a firm group,

$D_i^{age_a}$ = dummy variable for firm age in category a (a = 1 if age < 3; a = 2 if 3≤age < 10; a = 3 if age≥10),

$D_i^{size_s}$ = dummy variable for firm size in category s (s = 1 if size < 10; s = 2 if 10≤size < 50; s = 3 if 50≤size < 100; s = 4 if 100≤size < 250; s = 5 if size≥250),

$D_i^{branch_b}$ = dummy variable for branch b (b = NACE codes at the two-digit-level),

$D_i^{settlement_t}$ = dummy variable for settlement type in category t (t = 1 firm located in an agglomerations; t = 2 firm located in urbanized region; t = 3 firm located in rural region),

u_{ij} = disturbance term.

In the second step of the analysis, the residuals from each regression are used to define the corresponding manifest variable ($MV_{ij} = \hat{u}_{ij}$). Note that due to the bootstrapping technique employed in the sec-

[13] Before performing the estimation, we tested for multicollinearity between the MVs and found that it would not be a problem. The estimations were carried out using the following software: PLSGraph 3.0 and SmartPLS 2.0 with PLS algorithm settings, path weighting scheme, and standardization of manifest variables. Furthermore, we chose options for the bootstrapping procedure as suggested by Tenenhaus et al. (2005), namely, 500 resamples with the number of cases equal to the original sample size and, for sign changes, the option-construct level changes.

ond step, all statistical tests will remain appropriate even if estimates from a first-step regression are used as input in the second step.

The empirical strategy for testing our hypotheses (second stage of the analysis) consists of three steps. First, we aim to discover the determinants of innovativeness for research and company spin-offs, as well as for otherwise created firms, i.e., to test H1, H2a, and H3. To this end, the basic model is estimated separately for the subsamples of research spin-offs, company spin-offs, and otherwise created firms. Furthermore, the LV *cooperation* includes all cooperation linkages, i.e., both local and nonlocal ties.

Second, the impact of proximity to cooperation partners on firm innovativeness is investigated (H2b). Here, because the proximity issue appears to be of particular significance for the research spin-offs, we take only these firms into consideration. We use the basic model again, but LV *cooperation* is replaced by the frequency of *local* (set A), *only local* ($A \setminus B$), and *nonlocal* (set B) *cooperation* (see FIGURE 3).

[FIGURE 3 HERE]

In the third step, we analyze the extent to which innovativeness and firm performance depend on how the firm was created (H4a and H4b). To this end, the extended model is estimated for all firms together.

4.1 Determinants of Innovativeness: A Comparison of Research Spin-Offs, Company Spin-Offs, and Otherwise Created Firms

The estimation results of the model for the firm subsamples are presented in TABLES 5 through 7. TABLE 5 contains the relationships between the LVs (inner relations); TABLE 6 the R^2 determinant coefficients and f^2 effect size values. The relationships between the MVs and their LVs are shown in TABLE 7. Furthermore, in the model for the otherwise created firms, we can indicate the highest number of significant inner and outer relations, possibly because this subsample contains the largest number of cases. As a result, some of the paths turn out to be significant although the coefficients and their effect size values are very low. Thus, in our discussion of results, we will look at only those relationships between the LVs that have values higher than 0.10.[14]

In the research spin-offs model, two of four LVs capturing the assessment of locational conditions, namely, *research facilities* and *support*, appear to have a significantly positive impact on cooperation activities, innovativeness, and/or performance. The proximity to research institutes and universities directly strengthens cooperation activities and has a medium effect on explaining this LV (the

[14] Lohmöller (1989) finds to be significant only those standardized inner coefficients with a value higher than 0.10; further, Chin (1998b) suggests that standardized paths should be at least 0.20 in order to be considered meaningful and theoretically interesting.

value of the determination coefficient for the LV *cooperation* is moderate). As well, these locational conditions have a moderate effect on explaining innovativeness of the research spin-offs. However, this impact tends to occur indirectly via cooperation intensity. Furthermore, both the collaboration activities and the locational conditions capturing various types of support are driving forces behind innovativeness in the case of the research spin-offs (both have a very large, direct effect on explaining innovativeness). The innovativeness of these firms shows a substantial value for the determination coefficient. However, firm performance (the expected development of the market volume) is only weakly explained by innovativeness (direct effect).

The estimation results for company spin-offs and otherwise created firms are quite similar to each other. In both models, proximity to research facilities (particularly to research institutes, which is not surprising) positively influences cooperation intensity as well as innovativeness and firm performance. Additionally, in the case of otherwise created firms, the relationship between the LVs *support* and *innovativeness* appears to be significantly positive. The R^2 value of cooperation intensity for company spin-offs is nearly twice as high as the same value for firms created in other ways; nevertheless, it is still weak. As well, the LV *innovativeness* in both models is rather weakly explained. Cooperation intensity shows the highest effect size on innovation activities for both firm groups. Finally, in both cases, the positive relationship between innovativeness and expected firm performance is confirmed; the values of the determination coefficients for performance are, however, very low.

Surprisingly, the relationship between the locational condition *skilled labor* and cooperation activities, innovativeness, and firm performance could *not* be confirmed for any of the firm groups. Nevertheless, all firm groups, particularly the research spin-offs, have a relatively high share of employees with a university degree. This could imply that the nonlocal or extra-regional labor markets are more important sources of acquiring skilled workers for firms in knowledge-intensive sectors.[15]

Not all relationships between the LVs and their indicators (outer models) have the expected sign. This is especially the case for various support forms. These findings might be a result of dependence on support from these institutions by firms with shrinking market volume and/or a declining competitive position, which may tend to make these sorts of locational condition be negatively assessed.

Finally, in addition to analyzing the significant relationships between variables in the models for the three firm groups, we perform a direct comparison of the particular coefficients of the research and company spin-offs with the coefficients in the model for the otherwise created firms. The significance of the differences between the coefficients is calculated using the methodology proposed by Chin (2000).[16] The comparison results are set out in TABLE 5 and TABLE 7. The LV *support* has

[15] Using data from Finish high-technology firms, Simonen and McCann (2007) also do not find any positive effect of local labor acquisition on the firms' innovation behavior.
[16] Chin (2000) suggests executing the multi-group comparison on the basis of the standard errors for the structural paths provided in the resampling procedure and by treating these estimates in a parametric sense via t-tests. The complete formula for calculating the t-statistics for the difference in paths between groups is as follows:

significantly greater influence on innovativeness for the research spin-offs than for otherwise created firms. On the other hand, the impact of *support* on the intensity of cooperation activities is significantly smaller for the research spin-offs. In the model for company spin-offs, transportation infrastructure has significantly smaller influence on innovation than it does for otherwise created firms; however, this relationship turns out to be insignificant in the case of company spin-offs.

[TABLE 5, TABLE 6 AND TABLE 7 HERE]

4.2 Local vs. Nonlocal Cooperation Links and Innovativeness of Research Spin-Offs

In the second step of our analysis, we test H2b, i.e., whether local on nonlocal cooperation links are more conducive to the innovativeness of research spin-offs. Here, we focus on the effect size values f^2 and the values of the determination coefficient R^2 for the respective LVs, which are presented in TABLE 8.

In the model of cooperation intensity with local partners, innovativeness is determined in the first instance by the LVs *support* and *cooperation*—both variables show an equally high, and thus large, effect on explaining innovativeness—as well as by the proximity to research facilities (medium effect size value). In the case of the model with only local cooperation ties, support has a great deal of influence on innovativeness. However, here, purely local cooperation connections appear to have a rather small effect on stimulating innovation activities. Finally, for the model including nonlocal links, both cooperation intensity and support have a large impact on explaining innovativeness, but the effect size value of (nonlocal) *cooperation* is higher than that of *support*. Not surprisingly, nonlocal cooperation intensity is explained only very weakly by locational conditions.

Comparing the results from the models with local, only local, or nonlocal cooperation gives rise to some interesting conclusions about the importance of proximity to collaboration partners for innovativeness and performance of established research spin-offs. First, our analysis shows that nonlocal collaboration connections are more conducive to innovativeness of established research spin-offs. Second, the innovativeness of research spin-offs that mainly cooperate with local partners is particularly tied to various types of support.

[TABLE 8 HERE]

$$t=\frac{Path_1-Path_2}{\sqrt{\frac{(n_1-1)^2}{(n_1+n_2-2)}\times S.E._1^2+\frac{(n_2-1)^2}{(n_1+n_2-2)}\times S.E._2^2}\times\sqrt{\frac{1}{n_1}+\frac{1}{n_2}}},$$

where n_i represents the number of observations in sample i and $S.E._i$ is the standard error of the $Path_i$ calculated in the resampling procedure.

4.3 Impact of Type of Firm Entry on Firm Innovativeness and Performance

In the third and last step of our analysis, we investigate to what extent innovativeness and expected performance of established firms is influenced by how the firm was founded by estimating the extended version of our model for all firms simultaneously. None of the four postulated relationships between the two LVs *RSO* and *CSO* and the innovativeness and performance of established firms is significant. Moreover, *RSO* and *CSO* themselves appear to have no effect on explaining firm innovativeness and performance (TABLE 9 presents the calculated f^2 and R^2 values). Therefore, the higher innovativeness of established research spin-offs cannot be traced back to how the firm was created. Moreover, our results make clear that high intensity of cooperation activities is a driving force behind innovativeness of firms in knowledge-intensive sectors.

[TABLE 9 HERE]

5. Conclusions

In this paper, based on a sample of established research and company spin-offs and otherwise created firms from knowledge-intensive sectors, we analyzed the importance of locational conditions to cooperation activities and firm innovativeness. To this end, we developed a structural equation model that was estimated by employing the partial least squares method. Because of the high flexibility of this modeling approach, we were able to disentangle the effect of locational conditions on innovativeness by teasing out an indirect effect via the firm's collaboration behavior. Furthermore, in our analysis, we controlled firms' heterogeneity in terms of age, size, and affiliation with a firm group and economic sector, as well controlling for the effect of firm location settlement type.

Our results show that certain locational conditions, particularly close proximity to research institutes and various types of support, significantly strengthen the intensity of cooperation activities, mainly with local partners, for spin-offs. Furthermore, these locational conditions appear to play a very important role in the innovativeness of research spin-offs (captured as a direct effect). However, we find no effect of the other locational conditions included in our model, i.e., regional availability of skilled workers or transportation infrastructure, on the cooperation intensity and innovativeness of spin-off firms.

Nevertheless, our study confirms that cooperation activities are a crucial determinant of firm innovativeness. For company spin-offs, innovativeness can be moderately explained by cooperation intensity in various areas; for research spin-offs, the effect size of collaboration intensity on innovativeness is large. Contrary to the widespread view about the relevance of geographic proximity to cooperation partners for firm innovativeness, we find that nonlocal collaboration links are more conducive to innovativeness than are local ones. Finally, though the established research spin-offs tend to show higher innovativeness than the other groups of firms, our findings imply that the type of firm creation is, at the end of the day, not decisive for firm innovativeness in later phases of its development.

Our study has interesting implications for both practicing managers and public policymakers. The results of this paper indicate that managers can significantly improve their prospects for firm success in terms of innovativeness by enhancing networking and engaging in more frequent collaboration with a variety of partners, such as research institutes or other firms. Furthermore, in order to sustain the innovativeness of established spin-offs, a regional innovation policy should promote and provide incentives for firm cooperation activities, particularly with external or nonlocal partners. Finally, governmental R&D subsidies should be focused on research spin-offs, as the results show that the impact of on innovativeness of such funding is largest for this group.

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A. Tables

TABLE 1
NACE codes for high and medium-high technology manufacturing and KIS

		Research spin-offs		Company spin-offs		Otherwise created firms	
		Number	*% in spin-offs*	*Number*	*% in spin-offs*	*Number*	*% in other firms*
High and medium-high technology manufacturing							
	Manufacture of						
24	chemicals and chemical products	4	5.1	21	5.1	46	4.5
29	machinery and equipment	-	-	100	24.4	232	22.6
30	electrical and optical equipment	2	2.5	3	0.7	9	0.9
31	electrical machinery and apparatus	3	3.8	32	7.8	81	7.9
32	radio, television, and communication equipment and apparatus	-	-	-	-	-	-
33	medical, precision, and optical instruments, watches, and clocks	16	20.2	61	14.9	113	11.0
34	transport equipment	-	-	14	3.4	26	2.5
35	other transport equipment	-	-	12	2.9	10	1.00
Knowledge-intensive services							
61	water transport	-	-	-	-	-	-
62	air transport	-	-	-	-	-	-
64	post and telecommunications	-	-	-	-	-	-
65	financial intermediation	-	-	-	-	-	-
66	insurance and pension funding	-	-	-	-	1	0.1
67	activities auxiliary to financial intermediation	-	-	-	-	-	-
70	real estate activities	-	-	3	0.7	-	-
71	renting of machinery and equipment	-	-	10	2.4	31	3.0
72	computer and related activities	19	24.0	39	9.5	131	12.7
73	research and development	15	19.0	9	2.2	21	2.0
74	other business activities	20	25.3	104	25.4	322	31.3
80	education	-	-	1	0.2	1	0.1
85	health and social work	-	-	-	-	-	-
92	recreational, cultural, and sporting activities	-	-	1	0.2	4	0.4
Total		**79**	**100%**	**410**	**100%**	**1,028**	**100%**

TABLE 2
Firm distribution in various settlement types

Settlement type		Research spin-offs		Company spin-offs		Otherwise created firms	
		Number	*% in spin-offs*	*Number*	*% in spin-offs*	*Number*	*% in other firms*
1	agglomerations	46	58.2	201	49.3	539	52.6
2	urbanized regions	25	31.6	114	27.9	303	29.6
3	rural regions	8	10.1	93	22.8	182	17.8
Total		**79**	**100%**	**408**	**100%**	**1,024**	**100%**

NOTES: Number of missing values = 6

TABLE 3
Descriptive statistics

Variables	Research spin-offs N	Mean	SD	Company spin-offs N	Mean	SD	Otherwise created firms N	Mean	SD
Founding year	79	1995*	9.35	410	1994*	14.65	1024	1994*	19.49
Affiliation to a firm group	79	0.06	0.25	410	0.20+	0.43	1028	0.10	0.30
Number of employees in 2003/2004	78	14.10-	17.41	395	38.02+	73.25	1012	26.24	124.07
Number of employees with university degree in 2003/2004	77	7.68	8.31	373	8.43+	17.37	991	5.73	15.40
Relative frequency of employees with university degree in 2003/2004	77	0.61+	0.28	373	0.36	0.32	992	0.36	0.33
Turnover (EUR) in 2003/2004	74	1.00-	1.25	384	4.82	12.68	973	3.68	32.78
Export share (%) in 2003/2004	73	15.09+	22.58	363	12.43+	21.27	946	9.63	20.08
Investment intensity (%) in 2003/2004	69	0.09	0.16	365	0.06	0.09	939	0.07	0.12
Obtaining government aid for R&D	72	0.71+	0.46	269	0.38	0.49	637	0.38	0.49
Partner in innovation networks	79	0.30+	0.46	407	0.11	0.31	1020	0.10	0.29
LV: Skilled labor									
Assessment of the locational condition:									
L1: supply of skilled workers	79	2.80+	1.52	410	2.22	1.47	1028	2.13	1.51
L2: additional education supply	79	1.70	1.89	410	1.84	1.76	1028	1.67	1.75
LV: Transportation									
Assessment of the locational condition:									
T1: supra-regional transportation links	79	2.00	1.89	410	1.78	1.85	1028	1.63	1.79
T2: regional transportation links	79	1.68	1.86	410	1.55	1.83	1028	1.62	1.79
LV: Research facilities									
Assessment of the locational condition:									
R1: proximity to universities	79	2.58+	2.19	410	1.17	1.86	1028	1.06	1.80
R2: proximity to research institutes	79	2.49+	2.22	410	0.96	1.72	1028	0.77	1.58
LV: Support									
Assessment of the locational condition:									
S1: support of local financial institutions	79	1.16	1.38	410	1.40	1.54	1028	1.45	1.54
S2: support of job centers	79	0.43-	1.11	410	0.69	1.28	1028	0.71	1.31
S3: local government promotion	79	0.67	1.30	410	0.92	1.46	1028	0.86	1.36
S4: support of business development corporations	79	1.03	1.63	410	1.35+	1.70	1028	1.07	1.52
S5: state government promotion	79	1.56+	1.79	410	1.16	1.59	1028	1.04	1.44
S6: chambers' support	79	1.10	1.71	410	1.15	1.60	1028	1.09	1.53
LV: Cooperation									
Cooperation frequency in:									
C1: basic research	79	2.20+	1.51	410	1.42	0.93	1028	1.33	0.84
C2: product development	79	3.03+	1.41	410	2.15	1.34	1028	2.09	1.35
C3: process development	79	2.37+	1.46	410	1.80+	1.15	1028	1.65	1.12
C4: additional education	79	2.20	1.41	410	2.21+	1.36	1028	1.99	1.25
C5: sales	79	2.09	1.26	410	1.83	1.27	1028	1.95	1.35
LV: Innovativeness									
I1: new products in 2003/2004	79	0.90+	0.30	410	0.74	0.44	1028	0.71	0.45
I2: new processes in 2003/2004	79	0.44+	0.50	410	0.35	0.48	1028	0.32	0.47
I3: number of patent applications in 2003/2004	79	1.14+	2.34	410	0.41	1.41	1028	0.39	1.98
I4: deployment share in R&D in 2003	79	35.04+	31.84	410	10.60	19.92	1028	10.93	20.38
LV: Performance									
Assessment of the development of:									
P1: competition situation in 2005/2006	79	3.52+	0.86	410	3.31	0.79	1028	3.27	0.78
P2: market volume in the medium term	79	3.58+	1.10	410	3.10	1.11	1028	3.09	1.12

NOTES: In the case of * mean = median; t-tests on differences of means, + significantly larger, - significantly smaller than comparison group at 5% level.

TABLE 4
Cooperation activities of the research spin-offs: Partners and their headquarters

			Cooperation									
			Partners are				Partners' headquarters are					
	No cooperation		other firms		research facilities		local based		external		both local based and external	
Cooperation field	*Mean*	*SD*	*Mean*	*SD*	*Mean*	*SD*	*Mean*	*SD*	*Mean*	*SD*	*Mean*	*SD*
basic research	0.53	0.50	0.11	0.32	0.42	0.50	0.32	0.47	0.25	0.44	0.13	0.33
product development	0.22	0.41	0.49	0.50	0.43	0.50	0.57	0.50	0.43	0.50	0.23	0.42
process development	0.44	0.50	0.33	0.47	0.32	0.47	0.32	0.47	0.30	0.46	0.10	0.30
additional education	0.49	0.50	0.16	0.37	0.33	0.47	0.23	0.42	0.20	0.40	0.13	0.33
sales	0.49	0.50	0.39	0.49	0.05	0.22	0.33	0.47	0.32	0.47	0.08	0.27
Relative frequency	**0.44**		**0.30**		**0.31**		**0.35**		**0.30**		**0.13**	

TABLE 5
Estimation results for research spin-offs, company spin-offs, and otherwise created firms—inner relations

	Research spin-offs			**Company spin-offs**			**Otherwise created firms**		
	Cooperation	*Innovativeness*	*Performance*	*Cooperation*	*Innovativeness*	*Performance*	*Cooperation*	*Innovativeness*	*Performance*
Skilled labor	0.057	-0.151		0.086	0.055		0.036	0.005	
Transportation	0.152	-0.017		0.012	-0.065 -		0.000	0.095***	
Research facilities	0.375**	0.157		0.423***	0.181***		0.289***	0.112***	
Support	-0.208 -	0.489* +		0.061	0.113		0.124***	0.077***	
Cooperation		0.602**			0.340***			0.391***	
Innovativeness			0.279**			0.264***			0.251***

NOTES: 1. Bootstrapped t-values (not reported) based on 500 resamples: ***, **, and * refer to significance at the 1%, 5%, and 10% levels, respectively.
2. t-tests on differences of means, + significantly larger, - significantly smaller than comparison group at 5% level.

TABLE 6
Estimation results for research spin-offs, company spin-offs, and otherwise created firms—R^2 determination coefficient values and f^2 effect size values

	Research spin-offs			**Company spin-offs**			**Otherwise created firms**		
f^2 values	*Cooperation*	*Innovativeness*	*Performance*	*Cooperation*	*Innovativeness*	*Performance*	*Cooperation*	*Innovativeness*	*Performance*
Skilled labor	0.01	0.03	-0.01	0.01	0.01	0.00	0.00	0.00	0.00
Transportation	0.03	0.01	-0.01	0.00	0.00	0.00	0.00	0.01	0.00
Research facilities	0.05	**0.20**	-0.03	**0.18**	0.03	0.00	**0.09**	0.01	0.00
Support	**0.08**	**0.38**	-0.04	0.00	0.02	0.00	0.02	0.01	0.00
Cooperation	-	**0.44**	0.00	-	**0.11**	0.00	-	**0.16**	0.00
R^2 values	*0.283*	*0.498*	*0.067*	*0.222*	*0.244*	*0.070*	*0.119*	*0.232*	*0.063*

NOTES: Bold values show the largest f^2 effect of the respective LVs on explaining the dependent LV.

TABLE 7
Estimation results for research spin-offs, company spin-offs, and otherwise created firms—outer relations

MV	**Research spin-offs**	**Company spin-offs**	**Otherwise created firms**
L1	0.563	0.672***	1.012***
L2	0.725	0.571**	-0.042
T1	0.985	1.076***	1.149***
T2	0.030	-0.233	-0.412
R1	0.593	0.135	0.449***
R2	0.571	0.904***	0.633***
S1	-0.017	-0.053	-0.105
S2	0.501	-0.032	-0.259**
S3	0.251	-0.113	-0.363***
S4	-0.722*** -	0.596**	0.546***
S5	0.577*	0.726***	0.747***
S6	-0.357	-0.156	-0.183
C1	0.330	0.632***	0.405***
C2	0.650*	0.376***	0.573***
C3	0.316	0.382***	0.379***
C4	0.048	0.056	-0.100
C5	0.345	-0.090	-0.026
I1	0.277	0.204**	0.328***
I2	0.180	0.412***	0.202***
I3	0.674**	0.211**	0.221***
I4	0.411	0.723***	0.770***
P1	0.539	0.356*	0.448***
P2	0.694*	0.812***	0.731***

NOTES: 1. Bootstrapped t-values (not reported) based on 500 resamples: ***, **, and * refer to significance at the 1%, 5%, and 10% level, respectively.
2. t-tests on differences of means, + significantly larger, - significantly smaller than comparison group at 5% level.

TABLE 8
Estimation results for research spin-offs with various levels of cooperation intensity—R^2 determination coefficient values and f^2 effect size values

	Local cooperation [a]			**Only local cooperation [b]**			**Nonlocal cooperation [c]**		
f^2 values	*Cooperation*	*Innovativeness*	*Performance*	*Cooperation*	*Innovativeness*	*Performance*	*Cooperation*	*Innovativeness*	*Performance*
Skilled labor	0.00	0.02	0.00	0.00	0.01	0.00	0.02	0.00	0.00
Transportation	0.00	0.00	0.01	0.01	0.03	-0.01	0.02	0.02	0.01
Research facilities	**0.07**	**0.16**	-0.05	0.01	-0.01	-0.06	0.01	0.05	-0.01
Support	**0.05**	**0.28**	-0.02	**0.08**	**0.23**	-0.04	0.01	**0.23**	0.00
Cooperation	-	**0.28**	-0.01	-	0.06	-0.04	-	**0.33**	0.02
R^2 values	*0.254*	*0.436*	*0.058*	*0.184*	*0.320*	*0.029*	*0.073*	*0.459*	*0.082*

NOTES: Bold values show the largest f^2 effect of the respective LVs on explaining the dependent LV.
[a] Model with local cooperation (local links coexistent with nonlocal ties are not excluded).
[b] Model with only local cooperation (local links coexistent with nonlocal ties are excluded).
[c] Model with nonlocal cooperation (nonlocal links coexistent with local ties are not excluded).

TABLE 9
Estimation results for all firms (extended model)—R^2 determination coefficient values and f^2 effect size values

	All firms		
f^2 values	*Coop-eration*	*Innovati-veness*	*Perfor-mance*
Skilled labor	0.00	0.00	0.00
Transportation	0.00	0.00	0.00
Research facili-ties	**0.12**	0.01	0.00
Support	0.01	0.01	0.00
RSO	-	*0.00*	*0.00*
CSO	-	*0.00*	*0.00*
Cooperation	-	**0.14**	0.00
R^2 values	*0.157*	*0.224*	*0.070*

NOTES: Bold values show the largest f^2 effect of the respective LVs on explaining the dependent LV.

B. Figures

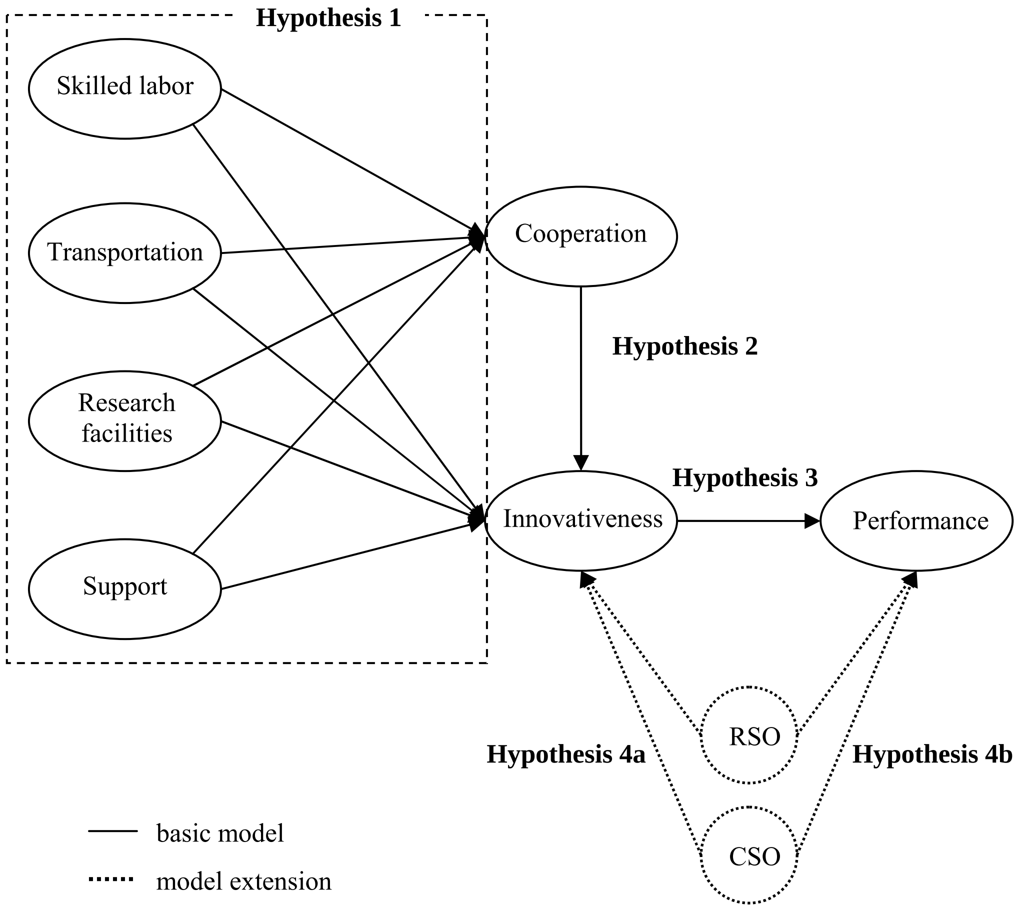

FIGURE 1 The structural equation model

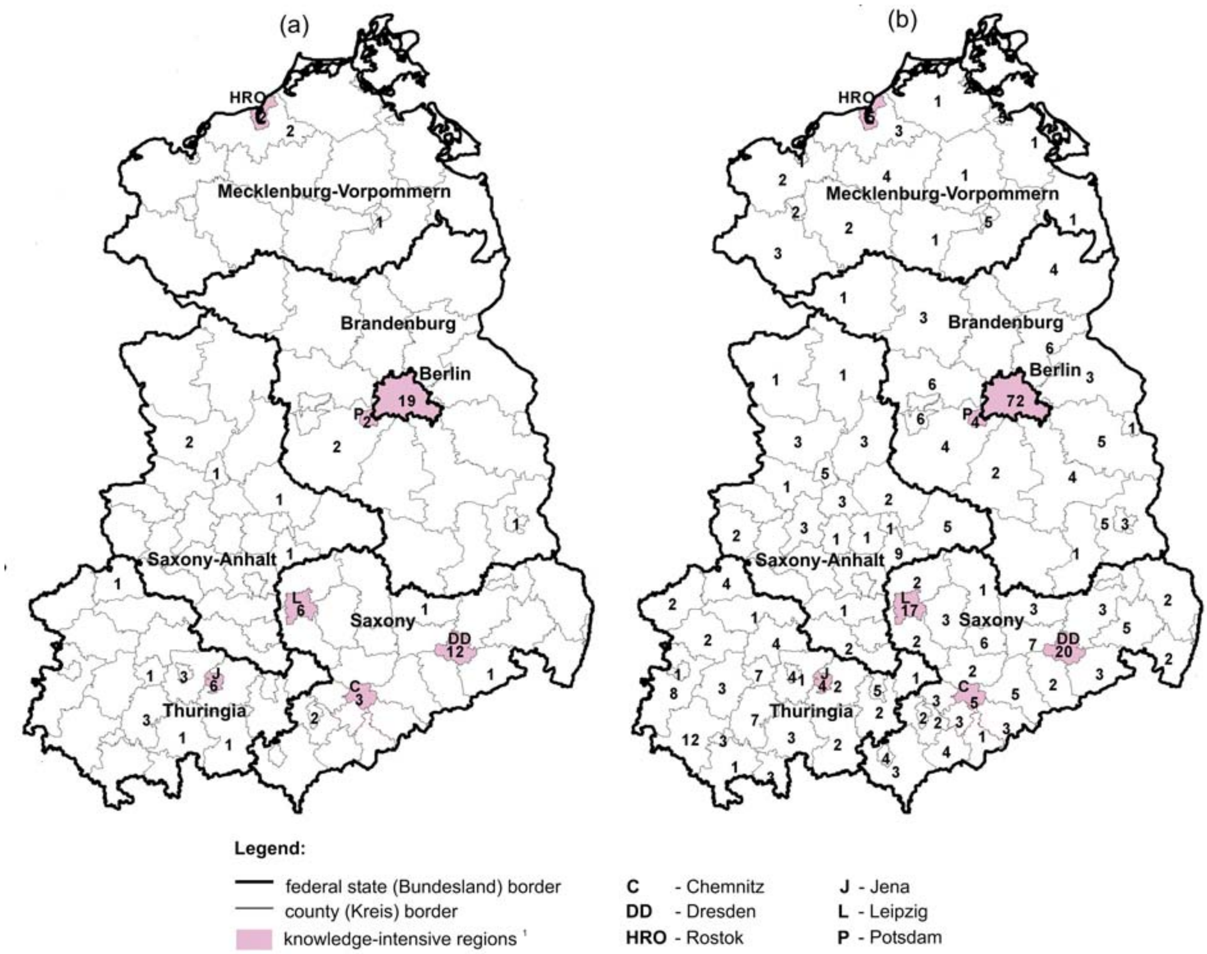

FIGURE 2 The geographical distribution of (a) research and (b) company spin-offs

SOURCE: [1] Federal Office for Building and Regional Planning

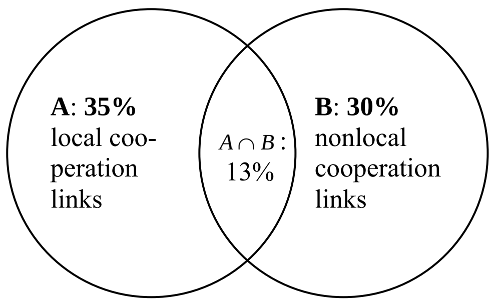

FIGURE 3 The location-orientated focus of cooperation links for research spin-offs

Appendix

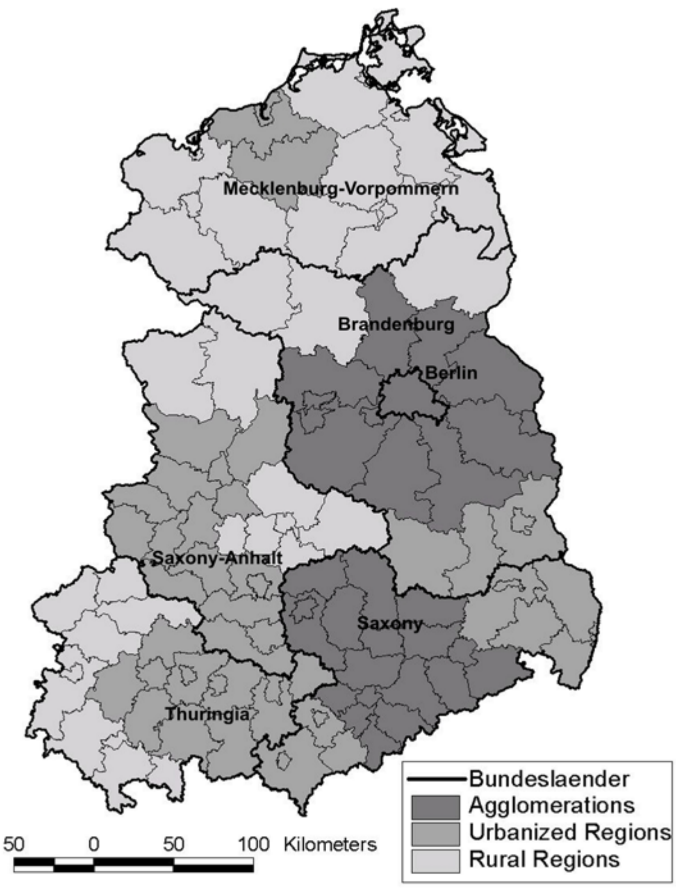

FIGURE A Assignment of the counties (Kreise) to settlement types